



# Appendices

## APPENDIX A-1

## U.S. Government Spacecraft Record

(Includes spacecraft from cooperating countries launched by U.S. launch vehicles.)

Calendar Year	Earth Orbit <sup>a</sup>		Earth Escape <sup>a</sup>	
	Success	Failure	Success	Failure
1957	0	1	0	0
1958	5	8	0	4
1959	9	9	1	2
1960	16	12	1	2
1961	35	12	0	2
1962	55	12	4	1
1963	62	11	0	0
1964	69	8	4	0
1965	93	7	4	1
1966	94	12	7	1 <sup>b</sup>
1967	78	4	10	0
1968	61	15	3	0
1969	58	1	8	1
1970	36	1	3	0
1971	45	2	8	1
1972	33	2	8	0
1973	23	2	3	0
1974	27	2	1	0
1975	30	4	4	0
1976	33	0	1	0
1977	27	2	2	0
1978	34	2	7	0
1979	18	0	0	0
1980	16	4	0	0
1981	20	1	0	0
1982	21	0	0	0
1983	31	0	0	0
1984	35	3	0	0
1985	37	1	0	0
1986	11	4	0	0
1987	9	1	0	0
1988	16	1	0	0
1989	24	0	2	0
1990	40	0	1	0
1991	32 <sup>c</sup>	0	0	0
1992	26 <sup>c</sup>	0	1	0
1993	28 <sup>c</sup>	1	1	0
1994	31 <sup>c</sup>	1	1	0
1995	24 <sup>c,d</sup>	2	1	0
1996	30	1	3	0
1997 (through September 30, 1997)	15 <sup>e</sup>	0	0	0
<b>TOTAL</b>	<b>1,387</b>	<b>149</b>	<b>89</b>	<b>15</b>

- a. The criterion of success or failure used is attainment of Earth orbit or Earth escape rather than judgment of mission success. "Escape" flights include all that were intended to go to at least an altitude equal to lunar distance from Earth.
- b. This Earth-escape failure did attain Earth orbit and, therefore, is included in the Earth-orbit success totals.
- c. This excludes commercial satellites. It counts separately spacecraft launched by the same launch vehicle.
- d. This counts the five orbital debris radar calibration spheres that were launched from STS-63 as one set of spacecraft.
- e. This includes the SSTI-Lewis spacecraft that began spinning out of control shortly after it achieved Earth orbit.

## World Record of Space Launches Successful in Attaining Earth Orbit or Beyond

(Enumerates launches rather than spacecraft; some launches orbited multiple spacecraft.)

Calendar Year	United States	USSR/ CIS	France <sup>a</sup>	Italy <sup>a</sup>	Japan	People's Republic of China	Australia	United Kingdom	European Space Agency	India	Israel
1957		2									
1958	5	1									
1959	10	3									
1960	16	3									
1961	29	6									
1962	52	20									
1963	38	17									
1964	57	30									
1965	63	48	1								
1966	73	44	1								
1967	57	66	2	1			1				
1968	45	74									
1969	40	70									
1970	28	81	2	1 <sup>b</sup>	1	1					
1971	30	83	1	2 <sup>b</sup>	2	1		1			
1972	30	74		1	1						
1973	23	86									
1974	22	81		2 <sup>b</sup>	1						
1975	27	89	3	1	2	3					
1976	26	99			1	2					
1977	24	98			2						
1978	32	88			3	1					
1979	16	87			2				1		
1980	13	89			2						1
1981	18	98			3	1			2		1
1982	18	101			1	1					
1983	22	98			3	1			2		1
1984	22	97			3	3			4		
1985	17	98			2	1			3		
1986	6	91			2	2			2		
1987	8	95			3	2			2		
1988	12	90			2	4			7		
1989	17	74			2				7		1
1990	27	75			3	5			5		1
1991	20 <sup>c</sup>	62			2	1			9		1
1992	31 <sup>c</sup>	55			2	3			7 <sup>b</sup>		2
1993	24 <sup>c</sup>	45			1	1			7 <sup>b</sup>		
1994	26 <sup>c</sup>	49			2	5			6 <sup>b</sup>		2
1995	27 <sup>c</sup>	33 <sup>b</sup>			1	2 <sup>b</sup>			12 <sup>b</sup>		1
1996	32 <sup>c</sup>	25			1	3 <sup>d</sup>			10		1
1997	25	18			1	4			7		1
<i>(through September 30, 1997)</i>											
TOTAL	1,108	2,543	10	8	51	46	1	1	93	10	3

- Since 1979, all launches for ESA member countries have been joint and are listed under ESA.
- Includes foreign launches of U.S. spacecraft.
- This includes commercial expendable launches and launches of the Space Shuttle, but because this table records launches rather than spacecraft, it does not include separate spacecraft released from the Shuttle.
- This includes the launch of ChinaSat 7, even though a third stage rocket failure led to a virtually useless orbit for this communications satellite.

## APPENDIX B

## Successful Launches to Orbit on U.S. Launch Vehicles October 1, 1996–September 30, 1997

Launch Date Spacecraft Name COSPAR Designation Launch Vehicle	Mission Objectives	Apogee and Perigee (km), Period (min), Inclination to Equator (°)	Remarks
<b>Nov. 7, 1996</b> Mars Global Surveyor 62A Delta II	Remote-sensing mission of Martian atmosphere and soil composition.	Martian orbit	
<b>Nov. 19, 1996</b> Space Shuttle <i>Columbia</i> STS-80 65A Space Shuttle 347 km	Deploy ORFEUS-SPAS and WSF-3 payloads.	358 km 347 km 1 hour 32 min 28.4°	Set record for longest Space Shuttle flight.
<b>Nov. 20, 1996</b> ORFEUS-SPAS 65B Space Shuttle	Astronomy telescope.	Orbital parameters similar to STS-80	U.S.-German telescope retrieved after several days.
<b>Nov. 23, 1996</b> WSF-3 65C Space Shuttle	Wake Shield Facility-3, a microgravity module.	Orbital parameters similar to STS-80	Retrieved on November 26, 1996.
<b>Nov. 21, 1996</b> Hot Bird 2 67A Atlas*	European communications spacecraft.	Geosynchronous	
<b>Dec. 4, 1996</b> Mars Pathfinder 68A Delta II	Planetary spacecraft with rover to explore Martian surface.		
<b>Dec. 18, 1996</b> Inmarsat 3 70A Atlas*	Communications satellite.	Geosynchronous	
<b>Dec. 20, 1996</b> USA 129 72A Titan IV	Military spacecraft.	Orbital parameters unavailable	
<b>Jan. 12, 1997</b> Space Shuttle <i>Atlantis</i> (STS-81) 1A Space Shuttle	Fifth Shuttle mission to <i>Mir</i> .	392 km 380 km 1 hour 32 minutes 51.6°	Jerry Linenger replaced John Blaha as U.S. resident on <i>Mir</i> .

## APPENDIX B

(Continued)

## Successful Launches to Orbit on U.S. Launch Vehicles October 1, 1996–September 30, 1997

Launch Date Spacecraft Name COSPAR Designation Launch Vehicle	Mission Objectives	Apogee and Perigee (km), Period (min), Inclination to Equator (°)	Remarks
<b>Feb. 11, 1997</b> Space Shuttle <i>Discovery</i> (STS-82) 4A Space Shuttle	Second servicing mission of the Hubble Space Telescope.	574 km 475 km 1 hour 35 minutes 28.5°	
<b>Feb. 17, 1997</b> JCSAT 7A Centaur*	Japanese communications spacecraft.	94,203 km 14,250 km 42 hours 14 minutes 6.3°	
<b>Feb. 24, 1997</b> USA 130 8A Titan IVB	Military spacecraft.	Orbital parameters unavailable	
<b>Mar. 8, 1997</b> Tempo 2 11A Atlas IIA*	Communications spacecraft.	Geosynchronous	
<b>Apr. 4, 1997</b> DMSP F14 (USA 131) 12A Titan II	Military spacecraft.	854 km 843 km 1 hour 42 minutes 98.9°	
<b>Apr. 4, 1997</b> Space Shuttle <i>Columbia</i> (STS-83) 13A Space Shuttle	Deployment of a Spacelab module configured as the first Microgravity Science Laboratory.	303 km 298 km 1 hour 31 minutes 28.4°	A Shuttle fuel cell malfunction necessitated an early termination of the mission. Reflown as STS-94.
<b>Apr. 21, 1997</b> Minisat 1 18A Pegasus XL*	Spanish microgravity research spacecraft.	581 km 562 km 1 hour 36 minutes 150.9°	
<b>Apr. 25, 1997</b> GOES-10 19A Atlas-Centaur	Meteorological spacecraft.	Geosynchronous	Will remain passively stored until GOES-8 or GOES-9 becomes inoperational.
<b>May 5, 1997</b> Iridium 4-8 20A-E Delta II*	Communications spacecraft.	642 km 629 km 1 hour 37 minutes 86.3°	
<b>May 15, 1997</b> Space Shuttle <i>Atlantis</i> (STS-84) 23A Space Shuttle	Sixth Shuttle mission to <i>Mir</i> .		Michael Foale replaced Jerry Linenger on <i>Mir</i> .

## APPENDIX B

(Continued)

## Successful Launches to Orbit on U.S. Launch Vehicles October 1, 1996–September 30, 1997

Launch Date Spacecraft Name COSPAR Designation Launch Vehicle	Mission Objectives	Apogee and Perigee (km), Period (min), Inclination to Equator (°)	Remarks
<b>May 20, 1997</b> Thor 2A 25A Delta II	Norwegian communications spacecraft.	Geosynchronous	
<b>July 1, 1997</b> Space Shuttle <i>Columbia</i> (STS-94) 32A Space Shuttle	Reflight of STS-83 and Microgravity Science Laboratory.	299 km 294 km 1 hour 31 minutes 28.5°	Mission proceeded successfully.
<b>July 9, 1997</b> Iridium 15, 17, 18, 20, and 21 34A-E Delta II*	Communications satellite.	645 km 635 km 1 hour 37 minutes 86.4°	
<b>July 23, 1997</b> Navstar 43 (USA 132) 35A Delta II	Global Positioning System (GPS) satellite.	20,224 km 19,903 km 11 hours 53 minutes 54.9°	
<b>July 28, 1997</b> Superbird C 36A Atlas IIAS*	Japanese communications satellite.	Geosynchronous	
<b>Aug. 1, 1997</b> Orbview 2 37A Pegasus XL*	Ocean monitoring satellite.	319 km 297 km 1 hour 31 minutes 90.7°	Formerly known as Seastar.
<b>Aug. 7, 1997</b> Space Shuttle <i>Discovery</i> (STS-85) 39A Space Shuttle	Deploy CRISTA-SPAS-2 infrared radiation monitor and the Hitchhiker package of four experiments on ultraviolet radiation.	309 km 298 km 1 hour 30 minutes 57.0°	The crew also successfully performed the Japanese Manipulator Flight Demonstration of a robotic arm.
<b>Aug. 7, 1997</b> CRISTA-SPAS-2 39B Space Shuttle	German scientific spacecraft.	Orbital parameters similar to STS-85	Retrieved by Shuttle crew after 9 days of free flight.
<b>Aug. 21, 1997</b> Iridium 26-22 43A-E Delta II*	Communications satellites.	525 km 505 km 1 hour 35 minutes 95.0°	
<b>Aug. 23, 1997</b> SSTI-Lewis 44A LMLV-1*	Environmental monitoring satellite.	299.5 km 283.2 km 1 hour 31 minutes 97.6°	A few days after launch, Lewis began spinning uncontrollably and with diminishing solar power.

## APPENDIX B

(Continued)

## Successful Launches to Orbit on U.S. Launch Vehicles October 1, 1996–September 30, 1997

Launch Date Spacecraft Name COSPAR Designation Launch Vehicle	Mission Objectives	Apogee and Perigee (km), Period (min), Inclination to Equator (°)	Remarks
<b>Aug. 25, 1997</b> Advanced Composition Explorer (ACE) 45A Delta II	Space physics scientific spacecraft.	1,256,768 km 179 km 1,398 hours 28.7°	
<b>Aug. 29, 1997</b> FORTE 47A Pegasus XL	Military arms control spacecraft.	833 km 799 km 1 hour 41 minutes 70.0°	
<b>Sep. 4, 1997</b> GE-3 50A Atlas IIAS*	Communications satellite.	Geosynchronous	
<b>Sep. 25, 1997</b> Space Shuttle <i>Atlantis</i> (STS-86) 55A Space Shuttle	Seventh Shuttle mission to <i>Mir</i> .	392 km 370 km 1 hour 32 minutes 1 hour 32 minutes 51.6°	David Wolf replaced Michael Foale on <i>Mir</i> .
<b>Sep. 26, 1997</b> Iridium 34, 35, 36, 37, and 19 56A-E Delta II*	Communications satellites.	559 km 542 km 1 hour 36 minutes 86.7°	

\*Commercial launch licensed as such by the Federal Aviation Administration.

## APPENDIX C

## U.S. and Russian Human Space Flights 1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Vostok 1	Apr. 12, 1961	Yury A. Gagarin	0:1:48	First human flight.
Mercury-Redstone 3	May 5, 1961	Alan B. Shepard, Jr.	0:0:15	First U.S. flight; suborbital.
Mercury-Redstone 4	July 21, 1961	Virgil I. Grissom	0:0:16	Suborbital; capsule sank after landing; astronaut safe.
Vostok 2	Aug. 6, 1961	German S. Titov	1:1:18	First flight exceeding 24 hrs.
Mercury-Atlas 6	Feb. 20, 1962	John H. Glenn, Jr.	0:4:55	First American to orbit.
Mercury-Atlas 7	May 24, 1962	M. Scott Carpenter	0:4:56	Landed 400 km beyond target.
Vostok 3	Aug. 11, 1962	Andriyan G. Nikolayev	3:22:25	First dual mission (with Vostok 4).
Vostok 4	Aug. 12, 1962	Pavel R. Popovich	2:22:59	Came within 6 km of Vostok 3.
Mercury-Atlas 8	Oct. 3, 1962	Walter M. Schirra, Jr.	0:9:13	Landed 8 km from target.
Mercury-Atlas 9	May 15, 1963	L. Gordon Cooper, Jr.	1:10:20	First U.S. flight exceeding 24 hrs.
Vostok 5	June 14, 1963	Valery F. Bykovskiy	4:23:6	Second dual mission (with Vostok 6).
Vostok 6	June 16, 1963	Valentina V. Tereshkova	2:22:50	First woman in space; within 5 km of Vostok 5.
Voskhod 1	Oct. 12, 1964	Vladimir M. Komarov Konstantin P. Feoktistov Boris G. Yegorov	1:0:17	First three-person crew.
Voskhod 2	Mar. 18, 1965	Pavel I. Belyayev	1:2:2	First extravehicular activity (EVA), by Leonov, 10 min.
Gemini 3	Mar. 23, 1965	Aleksey A. Leonov Virgil I. Grissom	0:4:53	First U.S. two-person flight; first manual maneuvers in orbit.
Gemini 4	June 3, 1965	John W. Young James A. McDivitt	4:1:56	21-min. EVA (White).
Gemini 5	Aug. 21, 1965	Edward H. White, II L. Gordon Cooper, Jr.	7:22:55	Longest duration human flight to date.
Gemini 7	Dec. 4, 1965	Charles Conrad, Jr. Frank Borman	13:18:35	Longest human flight to date.
Gemini 6-A	Dec. 15, 1965	James A. Lovell, Jr. Walter M. Schirra, Jr.	1:1:51	Rendezvous within 30 cm of Gemini 7.
Gemini 8	Mar. 16, 1966	Thomas P. Stafford Neil A. Armstrong	0:10:41	First docking of two orbiting spacecraft (Gemini 8 with Agena target rocket).
Gemini 9-A	June 3, 1966	David R. Scott Thomas P. Stafford	3:0:21	EVA; rendezvous.
Gemini 10	July 18, 1966	Eugene A. Cernan John W. Young	2:22:47	First dual rendezvous (Gemini 10 with Agena 10, then Agena 8).
Gemini 11	Sep. 12, 1966	Michael Collins Charles Conrad, Jr.	2:23:17	First initial-orbit docking; first tethered flight; highest Earth-orbit altitude (1,372 km.).
Gemini 12	Nov. 11, 1966	Richard F. Gordon, Jr. James A. Lovell, Jr.	3:22:35	Longest EVA to date (Aldrin, 5 hrs.).
Soyuz 1	Apr. 23, 1967	Edwin E. Aldrin, Jr. Vladimir M. Komarov	1:2:37	Cosmonaut killed in reentry accident.
Apollo 7	Oct. 11, 1968	Walter M. Schirra, Jr. Donn F. Eisele	10:20:9	First U.S. three-person mission.
Soyuz 3	Oct. 26, 1968	R. Walter Cunningham Georgiy T. Beregovoy	3:22:51	Maneuvered near uncrewed Soyuz 2.
Apollo 8	Dec. 21, 1968	Frank Borman James A. Lovell, Jr.	6:3:1	First human orbit(s) of Moon; first human departure from Earth's sphere of influence; highest speed attained in human flight to date.
Soyuz 4	Jan. 14, 1969	William A. Anders Vladimir A. Shatalov	2:23:23	Soyuz 4 and 5 docked and transferred two cosmonauts from Soyuz 5 to Soyuz 4.
Soyuz 5	Jan. 15, 1969	Boris V. Volynov Aleksey A. Yeliseyev	3:0:56	
Apollo 9	Mar. 3, 1969	Yevgeniy V. Khrunov James A. McDivitt David R. Scott Russell L. Schweickart	10:1:1	Successfully simulated in Earth orbit operation of lunar module to landing and takeoff from lunar surface and rejoining with command

APPENDIX C  
(Continued)  
**U.S. and Russian Human Space Flights**  
1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Apollo 10	May 18, 1969	Thomas P. Stafford John W. Young Eugene A. Cernan	8:0:3	Successfully demonstrated complete system, including lunar module to 14,300 m from the lunar surface.
Apollo 11	July 16, 1969	Neil A. Armstrong Michael Collins Edwin E. Aldrin, Jr.	8:3:9	First human landing on lunar surface and safe return to Earth. First return of rock and soil samples to Earth and human deployment of experiments on lunar surface.
Soyuz 6	Oct. 11, 1969	Georgiy Shonin Valery N. Kubasovf	4:22:42	Soyuz 6, 7, and 8 operated as a group flight without actually docking. Each conducted certain experiments,
Soyuz 7	Oct. 12, 1969	A. V. Filipchenko Viktor N. Gorbatko Vladislav N. Volkov	4:22:41	including welding and Earth and celestial observation.
Soyuz 8	Oct. 13, 1969	Vladimir A. Shatalov Aleksy S. Yeliseyev	4:22:50	
Apollo 12	Nov. 14, 1969	Charles Conrad, Jr. Richard F. Gordon, Jr. Alan L. Bean	10:4:36	Second human lunar landing explored surface of Moon and retrieved parts of Surveyor 3 spacecraft, which landed in Ocean of Storms on Apr. 19, 1967.
Apollo 13	Apr. 11, 1970	James A. Lovell, Jr. Fred W. Haise, Jr. John L. Swigert, Jr.	5:22:55	Mission aborted; explosion in service module. Ship circled Moon, with crew using LM as "lifeboat" until just before reentry.
Soyuz 9	June 1, 1970	Andriyan G. Nikolayev Vitaliy I. Sevastyanov	17:16:59	Longest human spaceflight to date.
Apollo 14	Jan. 31, 1971	Alan B. Shepard, Jr. Stuart A. Roosa Edgar D. Mitchell	9:0:2	Third human lunar landing. Mission demonstrated pinpoint landing capability and continued human exploration.
Soyuz 10	Apr. 22, 1971	Vladimir A. Shatalov Aleksy S. Yeliseyev Nikolay N. Rukavishnikov	1:23:46	Docked with Salyut 1, but crew did not board space station launched Apr. 19. Crew recovered Apr. 24, 1971.
Soyuz 11	June 6, 1971	Georgiy T. Dobrovolskiy Vladislav N. Volkov Viktor I. Patsayev	23:18:22	Docked with Salyut 1, and Soyuz 11 crew occupied space station for 22 days. Crew perished in final phase of Soyuz 11 capsule recovery on June 30, 1971.
Apollo 15	July 26, 1971	David R. Scott Alfred M. Worden James B. Irwin	12:7:12	Fourth human lunar landing and first Apollo "J" series mission, which carried Lunar Roving Vehicle. Worden's inflight EVA of 38 min., 12 sec. was performed during return trip.
Apollo 16	Apr. 16, 1972	John W. Young Charles M. Duke, Jr. Thomas K. Mattingly II	11:1:51	Fifth human lunar landing, with roving vehicle.
Apollo 17	Dec. 7, 1972	Eugene A. Cernan Harrison H. Schmitt Ronald E. Evans	12:13:52	Sixth and final Apollo human lunar landing, again with roving vehicle.
Skylab 2	May 25, 1973	Charles Conrad, Jr. Joseph P. Kerwin Paul J. Weitz	28:0:50	Docked with Skylab 1 (launched uncrewed May 14) for 28 days. Repaired damaged station.
Skylab 3	July 28, 1973	Alan L. Bean Jack R. Lousma Owen K. Garriott	59:11:9	Docked with Skylab 1 for more than 59 days.
Soyuz 12	Sep. 27, 1973	Vasiliy G. Lazarev Oleg G. Makarov	1:23:16	Checkout of improved Soyuz.

## APPENDIX C

(Continued)

## U.S. and Russian Human Space Flights 1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Skylab 4	Nov. 16, 1973	Gerald P. Carr Edward G. Gibson William R. Pogue	84:1:16	Docked with Skylab 1 in long-duration mission; last of Skylab program.
Soyuz 13	Dec. 18, 1973	Petr I. Klimuk Valentin V. Lebedev	7:20:55	Astrophysical, biological, and Earth resources experiments.
Soyuz 14	July 3, 1974	Pavel R. Popovich Yury P. Artyukhin	15:17:30	Docked with Salyut 3 and Soyuz 14 crew occupied space station.
Soyuz 15	Aug. 26, 1974	Gennady V. Sarafanov Lev S. Demin	2:0:12	Rendezvoused but did not dock with Salyut 3.
Soyuz 16	Dec. 2, 1974	Anatoly V. Filipchenko Nikolay N. Rukavishnikov	5:22:24	Test of Apollo-Soyuz Test Project (ASTP) configuration.
Soyuz 17	Jan. 10, 1975	Aleksay A. Gubarev Georgiy M. Grechko	29:13:20	Docked with Salyut 4 and occupied station.
Anomaly (Soyuz 18A)	Apr. 5, 1975	Vasily G. Lazarev Oleg G. Makarov	0:0:20	Soyuz stages failed to separate; crew recovered after abort.
Soyuz 18	May 24, 1975	Petr I. Klimuk Vitaliy I. Sevastyanov	62:23:20	Docked with Salyut 4 and occupied station.
Soyuz 19	July 15, 1975	Aleksey A. Leonov Valery N. Kubasov	5:22:31	Target for Apollo in docking and joint experiments of ASTP mission.
Apollo	July 15, 1975	Thomas P. Stafford Donald K. Slayton Vance D. Brand	9:1:28	Docked with Soyuz 19 in joint (ASTP) experiments of ASTP mission.
Soyuz 21	July 6, 1976	Boris V. Volynov Vitaliy M. Zholobov	48:1:32	Docked with Salyut 5 and occupied station.
Soyuz 22	Sep. 15, 1976	Valery F. Bykovskiy Vladimir V. Aksekov	7:21:54	Earth resources study with multispectral camera system.
Soyuz 23	Oct. 14, 1976	Vyacheslav D. Zudov Valery I. Rozhdestvenskiy	2:0:6	Failed to dock with Salyut 5.
Soyuz 24	Feb. 7, 1977	Viktor V. Gorbatko Yury N. Glazkov	17:17:23	Docked with Salyut 5 and occupied station.
Soyuz 25	Oct. 9, 1977	Vladimir V. Kovalenok Valery V. Ryumin	2:0:46	Failed to achieve hard dock with Salyut 6 station.
Soyuz 26	Dec. 10, 1977	Yury V. Romanenko Georgiy M. Grechko	37:10:6	Docked with Salyut 6. Crew returned in Soyuz 27; crew duration 96 days, 10 hrs.
Soyuz 27	Jan. 10, 1978	Vladimir A. Dzhanibekov Oleg G. Makarov	64:22:53	Docked with Salyut 6. Crew returned in Soyuz 26; crew duration 5 days, 22 hrs., 59 min.
Soyuz 28	Mar. 2, 1978	Aleksey A. Gubarev Vladimir Remeck	7:22:17	Docked with Salyut 6. Remeck was first Czech cosmonaut to orbit.
Soyuz 29	June 15, 1978	Vladimir V. Kovalenok Aleksandr S. Ivanchenkov	9:15:23	Docked with Salyut 6. Crew returned in Soyuz 31; crew duration 139 days, 14 hrs., 48 min.
Soyuz 30	June 27, 1978	Petr I. Klimuk Mirosław Hermaszewski	7:22:4	Docked with Salyut 6. Hermaszewski was first Polish cosmonaut to orbit.
Soyuz 31	Aug. 26, 1978	Valery F. Bykovskiy Sigmund Jaehn	67:20:14	Docked with Salyut 6. Crew returned in Soyuz 29; crew duration 7 days, 20 hrs., 49 min. Jaehn was first German Democratic Republic cosmonaut to orbit.
Soyuz 32	Feb. 25, 1979	Vladimir A. Lyakhov Valery V. Ryumin Nikolay N. Rukavishnikov	108:4:24	Docked with Salyut 6. Crew returned in Soyuz 34; crew duration 175 days, 36 min.
Soyuz 33	Apr. 10, 1979	Georgi I. Ivanov	1:23:1	Failed to achieve docking with Salyut 6 station. Ivanov was first Bulgarian cosmonaut to orbit.
Soyuz 34	June 6, 1979	(unmanned at launch)	7:18:17	Docked with Salyut 6, later served as ferry for Soyuz 32 crew while Soyuz 32 returned without a crew.

APPENDIX C  
(Continued)  
**U.S. and Russian Human Space Flights**  
1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Soyuz 35	Apr. 9, 1980	Leonid I. Popov Valery V. Ryumin	55:1:29	Docked with Salyut 6. Crew returned in Soyuz 37. Crew duration 184 days, 20 hrs., 12 min.
Soyuz 36	May 26, 1980	Valery N. Kubasov Bertalan Farkas	65:20:54	Docked with Salyut 6. Crew returned in Soyuz 35. Crew duration 7 days, 20 hrs., 46 min. Farkas was first Hungarian to orbit.
Soyuz T-2	June 5, 1980	Yury V. Malyshev Vladimir V. Akseonov	3:22:21	Docked with Salyut 6. First crewed flight of new-generation ferry.
Soyuz 37	July 23, 1980	Viktor V. Gorbatko Pham Tuan	79:15:17	Docked with Salyut 6. Crew returned in Soyuz 36. Crew duration 7 days, 20 hrs., 42 min. Pham was first Vietnamese to orbit.
Soyuz 38	Sep. 18, 1980	Yury V. Romanenko Arnaldo Tamayo Mendez	7:20:43	Docked with Salyut 6. Tamayo was first Cuban to orbit.
Soyuz T-3	Nov. 27, 1980	Leonid D. Kizim Oleg G. Makarov Gennady M. Strekalov	12:19:8	Docked with Salyut 6. First three-person flight in Soviet program since 1971.
Soyuz T-4	Mar. 12, 1981	Vladimir V. Kovalenok Viktor P. Savinykh	74:18:38	Docked with Salyut 6.
Soyuz 39	Mar. 22, 1981	Vladimir A. Dzhanibekov Jugderdemidiyn Gurragcha	7:20:43	Docked with Salyut 6. Gurragcha first Mongolian cosmonaut to orbit.
Space Shuttle <i>Columbia</i> (STS-1)	Apr. 12, 1981	John W. Young Robert L. Crippen	2:6:21	First flight of Space Shuttle; tested spacecraft in orbit. First landing of airplane-like craft from orbit for reuse.
Soyuz 40 cosmonaut	May 14, 1981	Leonid I. Popov Dumitru Prunariu	7:20:41	Docked with Salyut 6. Prunariu first Romanian to orbit.
Space Shuttle <i>Columbia</i> (STS-2)	Nov. 12, 1981	Joe H. Engle Richard H. Truly	2:6:13	Second flight of Space Shuttle; first scientific payload (OSTA 1). Tested remote manipulator arm. Returned for reuse.
Space Shuttle <i>Columbia</i> (STS-3)	Mar. 22, 1982	Jack R. Lousma C. Gordon Fullerton	8:4:49	Third flight of Space Shuttle; second scientific payload (OSS 1). Second test of remote manipulator arm. Flight extended 1 day because of flooding at primary landing site; alternate landing site used. Returned for reuse.
Soyuz T-5	May 13, 1982	Anatoly Berezovoy Valentin Lebedev	211:9:5	Docked with Salyut 7. Crew duration of 211 days. Crew returned in Soyuz T-7.
Soyuz T-6	June 24, 1982	Vladimir Dzhanibekov Aleksandr Ivanchenkov Jean-Loup Chrétien	7:21:51	Docked with Salyut 7. Chrétien first French cosmonaut to orbit.
Space Shuttle <i>Columbia</i> (STS-4)	June 27, 1982	Thomas K. Mattingly II Henry W. Hartsfield, Jr.	7:1:9	Fourth flight of Space Shuttle; first DoD payload; additional scientific payloads. Returned July 4. Completed testing program. Returned for reuse.
Soyuz T-7	Aug. 19, 1982	Leonid Popov Aleksandr Serebrov Svetlana Savitskaya	7:21:52	Docked with Salyut 7. Savitskaya second woman to orbit. Crew returned in Soyuz T-5.
Space Shuttle <i>Columbia</i> (STS-5)	Nov. 11, 1982	Vance D. Brand Robert F. Overmyer Joseph P. Allen William B. Lenoir	5:2:14	Fifth flight of Space Shuttle; first operational flight; launched two commercial satellites (SBS 3 and Anik C-3); first flight with four crew members. EVA test canceled when spacesuits malfunctioned.
Space Shuttle <i>Challenger</i> (STS-6)	Apr. 4, 1983	Paul J. Weitz Karol J. Bobko Donald H. Peterson Story Musgrave	5:0:24	Sixth flight of Space Shuttle; launched TDRS-1.

## APPENDIX C

(Continued)

## U.S. and Russian Human Space Flights 1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Soyuz T-8	Apr. 20, 1983	Vladimir Titov Gennady Strekalov Aleksandr Serebrov	2:0:18	Failed to achieve docking with Salyut 7 station.
Space Shuttle <i>Challenger</i> (STS-7)	June 18, 1983	Robert L. Crippen Frederick H. Hauck John M. Fabian Sally K. Ride Norman T. Thagard	6:2:24	Seventh flight of Space Shuttle; launched two commercial satellites (Anik C-2 and Palapa B-1); also launched and retrieved SPAS 01; first flight with five crew members, including first woman U.S. astronaut.
Soyuz T-9	June 28, 1983	Vladimir Lyakhov Aleksandr Aleksandrov	149:9:46	Docked with Salyut 7 station.
Space Shuttle <i>Challenger</i> (STS-8)	Aug. 30, 1983	Richard H. Truly Daniel C. Brandenstein Dale A. Gardner Guion S. Bluford, Jr. William E. Thornton	6:1:9	Eighth flight of Space Shuttle; launched one commercial satellite (Insat 1-B); first flight of U.S. black astronaut.
Space Shuttle <i>Columbia</i> (STS-9)	Nov. 28, 1983	John W. Young Brewster W. Shaw Owen K. Garriott Robert A. R. Parker Byron K. Lichtenberg Ulf Merbold	10:7:47	Ninth flight of Space Shuttle; first flight of Spacelab 1; first flight of six crew members, one of whom was West German; first non-U.S. astronaut to fly in U.S. space program (Merbold).
Space Shuttle <i>Challenger</i> (STS 41-B)	Feb. 3, 1984	Vance D. Brand Robert L. Gibson Bruce McCandless Ronald E. McNair Robert L. Stewart	7:23:16	Tenth flight of Space Shuttle; two communication satellites failed to achieve orbit; first use of Manned Maneuvering Unit in space.
Soyuz T-10	Feb. 8, 1984	Leonid Kizim Vladimir Solovev Oleg Atkov	62:22:43	Docked with Salyut 7 station. Crew set space duration record of 237 days. Crew returned in Soyuz T-11.
Soyuz T-11	Apr. 3, 1984	Yury Malyshev Gennady Strekalov Rakesh Sharma	181:21:48	Docked with Salyut 7 station. Sharma first Indian in space. Crew returned in Soyuz T-10.
Space Shuttle <i>Challenger</i> (STS 41-C)	Apr. 6, 1984	Robert L. Crippen Frances R. Scobee Terry J. Hart George D. Nelson James D. van Hoften	6:23:41	Eleventh flight of Space Shuttle; deployment of Long-Duration Exposure Facility (LDEF-1) for later retrieval; Solar Maximum Satellite retrieved, repaired, and redeployed.
Soyuz T-12	July 17, 1984	Vladimir Dzhanibekov Svetlana Savitskaya Igor Volk	11:19:14	Docked with Salyut 7 station. First female EVA.
Space Shuttle <i>Discovery</i> (STS 41-D)	Aug. 30, 1984	Henry W. Hartsfield Michael L. Coats Richard M. Mullane Steven A. Hawley Judith A. Resnick Charles D. Walker	6:0:56	Twelfth flight of Space Shuttle. First flight of U.S. nonastronaut.
Space Shuttle <i>Challenger</i> (STS 41-G)	Oct. 5, 1984	Robert L. Crippen Jon A. McBride Kathryn D. Sullivan Sally K. Ride David Leestma Paul D. Scully-Power Marc Garneau	8:5:24	Thirteenth flight of Space Shuttle; first with seven crew members, including first flight of two U.S. women and one Canadian (Garneau).

APPENDIX C  
(Continued)  
**U.S. and Russian Human Space Flights**  
1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Space Shuttle <i>Discovery</i> (STS 51-A)	Nov. 8, 1984	Frederick H. Hauck David M. Walker Joseph P. Allen Anna L. Fisher Dale A. Gardner	7:23:45	Fourteenth flight of Space Shuttle; first retrieval and return of two disabled communications satellites (Westar 6, Palapa B2) to Earth.
Space Shuttle <i>Discovery</i> (STS 51-C)	Jan. 24, 1985	Thomas K. Mattingly Loren J. Shriver Ellison S. Onizuka James F. Buchli Gary E. Payton	3:1:33	Fifteenth STS flight. Dedicated DoD mission.
Space Shuttle <i>Discovery</i> (STS 51-D)	Apr. 12, 1985	Karol J. Bobko Donald E. Williams M. Rhea Seddon S. David Griggs Jeffrey A. Hoffman Charles D. Walker E. J. Garn	6:23:55	Sixteenth STS flight. Two communications satellites. First U.S. Senator in space (Garn).
Space Shuttle <i>Challenger</i> (STS 51-B)	Apr. 29, 1985	Robert F. Overmyer Frederick D. Gregory Don L. Lind Norman E. Thagard William E. Thornton Lodewijk van den Berg Taylor Wang	7:0:9	Seventeenth STS flight. Spacelab-3 in cargo bay of Shuttle.
Soyuz T-13	June 5, 1985	Vladimir Dzhanibekov Viktor Savinykh	112:3:12	Repair of Salyut-7. Dzhanibekov returned to Earth with Grechko on Soyuz T-13 spacecraft, Sept. 26, 1985.
Space Shuttle <i>Discovery</i> (STS 51-G)	June 17, 1985	Daniel C. Brandenstein John O. Creighton Shannon W. Lucid John M. Fabian Steven R. Nagel Patrick Baudry Prince Sultan Salman Al-Saud	7:1:39	Eighteenth STS flight. Three communications satellites. One reusable payload, Spartan-1. First U.S. flight with French and Saudi Arabian crew members.
Space Shuttle <i>Challenger</i> (STS 51-F)	July 29, 1985	Charles G. Fullerton Roy D. Bridges Karl C. Henize Anthony W. England F. Story Musgrave Loren W. Acton John-David F. Bartoe	7:22:45	Nineteenth STS flight. Spacelab-2 in cargo bay.
Space Shuttle <i>Discovery</i> (STS 51-I)	Aug. 27, 1985	Joe H. Engle Richard O. Covey James D. van Hoften William F. Fisher John M. Lounge	7:2:18	Twentieth STS flight. Launched three communications satellites. Repaired Syncom IV-3.
Soyuz T-14	Sep. 17, 1985	Vladimir Vasyutin Georgiy Grechko Aleksandr Volkov	64:21:52	Docked with Salyut 7 station. Viktor Savinykh, Aleksandr Volkov, and Vladimir Vasyutin returned to Earth Nov. 21, 1985, when Vasyutin became ill.
Space Shuttle <i>Atlantis</i> (STS 51-J)	Oct. 3, 1985	Karol J. Bobko Ronald J. Grabe Robert A. Stewart David C. Hilmers William A. Pailles	4:1:45	Twenty-first STS flight. Dedicated DoD mission.

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(Continued)

## U.S. and Russian Human Space Flights 1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Space Shuttle <i>Challenger</i> (STS 61-A)	Oct. 30, 1985	Henry W. Hartsfield Steven R. Nagel Bonnie J. Dunbar James F. Buchli Guion S. Bluford, Jr. Ernst Messerschmid Reinhard Furrer (FRG) Wubbo J. Ockels (ESA)	7:0:45	Twenty-second STS flight. Dedicated German Spacelab D-1 in shuttle cargo bay.
Space Shuttle <i>Atlantis</i> (STS 61-B)	Nov. 27, 1985	Brewster H. Shaw Bryan D. O'Connor Mary L. Cleve Sherwood C. Spring Jerry L. Ross Rudolfo Neri Vela Charles D. Walker	6:22:54	Twenty-third STS flight. Launched three communications satellites. First flight of Mexican astronaut (Neri Vela).
Space Shuttle <i>Columbia</i> (STS 61-C)	Jan. 12, 1986	Robert L. Gibson Charles F. Bolden Jr. Franklin Chang-Diaz Steve A. Hawley George D. Nelson Roger Cenker Bill Nelson	6:2:4	Twenty-fourth STS flight. Launched one communications satellite. First member of U.S. House of Representatives in space (Bill Nelson).
Soyuz T-15	Mar. 13, 1986	Leonid Kizim Vladimir Solovyov	125:1:1	Docked with <i>Mir</i> space station on May 5/6 transferred to Salyut 7 complex. On June 25/26 transferred from Salyut 7 back to <i>Mir</i> .
Soyuz TM-2	Feb. 5, 1987	Yury Romanenko Aleksandr Laveykin	174:3:26	Docked with <i>Mir</i> space station. Romanenko established long-distance stay in space record of 326 days.
Soyuz TM-3	July 22, 1987	Aleksandr Viktorenko Aleksandr Aleksandrov Mohammed Faris	160:7:16	Docked with <i>Mir</i> space station. Aleksandr Aleksandrov remained in <i>Mir</i> 160 days, returned with Yury Romanenko. Viktorenko and Faris returned in Soyuz TM-2, July 30, with Aleksandr Laveykin who experienced medical problems. Faris first Syrian in space.
Soyuz TM-4	Dec. 21, 1987	Vladimir Titov Musa Manarov Anatoly Levchenko	180:5	Docked with <i>Mir</i> space station. Crew of Yury Romanenko, Aleksandr Aleksandrov, and Anatoly Levchenko returned Dec. 29 in Soyuz TM-3.
Soyuz TM-5	June 7, 1988	Viktor Savinykh Anatoly Solovyev Aleksandur Aleksandrov	9:20:13	Docked with <i>Mir</i> space station; Aleksandrov first Bulgarian in space. Crew returned Jun. 17 in Soyuz TM-4.
Soyuz TM-6	Aug. 29, 1988	Vladimir Lyakhov Valery Polyakov Abdul Mohmand	8:19:27	Docked with <i>Mir</i> space station; Mohmand first Afghanistani in space. Crew returned Sept. 7, in Soyuz TM-5.
Space Shuttle <i>Discovery</i> (STS-26)	Sep. 29, 1988	Frederick H. Hauck Richard O. Covey John M. Lounge David C. Hilmers George D. Nelson	4:1	Twenty-sixth STS flight. Launched TDRS-3.
Soyuz TM-7	Nov. 26, 1988	Aleksandr Volkov Sergey Krikalev Jean-Loup Chrétien	151:11	Docked with <i>Mir</i> space station. Soyuz TM-6 returned with Chrétien, Vladimir Titov, and Musa Manarov. Titov and Manarov completed 366-day mission Dec. 21. Crew of Krikalev, Volkov, and Valery Polyakov returned Apr. 27, 1989, in Soyuz TM-7.

APPENDIX C  
(Continued)  
**U.S. and Russian Human Space Flights**  
1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Space Shuttle <i>Atlantis</i> (STS-27)	Dec. 2, 1988	Robert "Hoot" Gibson Guy S. Gardner Richard M. Mullane Jerry L. Ross William M. Shepherd	4:9:6	Twenty-seventh STS flight. Dedicated DoD mission.
Space Shuttle <i>Discovery</i> (STS-29)	Mar. 13, 1989	Michael L. Coats John E. Blaha James P. Baglian James F. Buchli Robert C. Springer	4:23:39	Twenty-eighth STS flight. Launched TDRS-4.
Space Shuttle <i>Atlantis</i> (STS-30)	May 4, 1989	David M. Walker Ronald J. Grabe Nomman E. Thagard Mary L. Cleave Mark C. Lee	4:0:57	Twenty-ninth STS flight. Venus orbiter Magellan launched.
Space Shuttle <i>Columbia</i> (STS-28)	Aug. 8, 1989	Brewster H. Shaw Richard N. Richards James C. Adamson David C. Leestma Mark N. Brown	5:1	Thirtieth STS flight. Dedicated DoD mission.
Soyuz TM-8	Sep. 5, 1989	Aleksandr Viktorenko Aleksandr Serebrov	166:6	Docked with <i>Mir</i> space station. Crew of Viktorenko and Serebrov returned in Soyuz TM-8, Feb. 9, 1990.
Space Shuttle <i>Atlantis</i> (STS-34)	Oct. 18, 1989	Donald E. Williams Michael J. McCulley Shannon W. Lucid Franklin R. Chang-Diaz Ellen S. Baker	4:23:39	Thirty-first STS flight. Launched Jupiter probe and orbiter Galileo.
Space Shuttle <i>Discovery</i> (STS-33)	Nov. 23, 1989	Frederick D. Gregory John E. Blaha Kathryn C. Thornton F. Story Musgrave Manley L. "Sonny" Carter	5:0:7	Thirty-second STS flight. Dedicated DoD mission.
Space Shuttle <i>Columbia</i> (STS-32)	Jan. 9, 1990	Daniel C. Brandenstein James D. Wetherbee Bonnie J. Dunbar Marsha S. Ivins G. David Low	10:21	Thirty-third STS flight. Launched Syncom IV-5 and retrieved LDEF.
Soyuz TM-9	Feb. 11, 1990	Anatoly Solovyov Aleksandr Balandin	178:22:19	Docked with <i>Mir</i> space station. Crew returned Aug. 9, 1990, in Soyuz TM-9.
Space Shuttle <i>Atlantis</i> (STS-36)	Feb. 28, 1990	John O. Creighton John H. Casper David C. Hilmers Richard H. Mullane Pierre J. Thuot	4:10:19	Thirty-fourth STS flight. Dedicated DoD mission.
Space Shuttle <i>Discovery</i> (STS-31)	Apr. 24, 1990	Loren J. Shriver Charles F. Bolden, Jr. Steven A. Hawley Bruce McCandless II Kathryn D. Sullivan	5:1:16	Thirty-fifth STS flight. Launched Hubble Space Telescope (HST).
Soyuz TM-10	Aug. 1, 1990	Gennady Manakov Gennady Strekalov	130:20:36	Docked with <i>Mir</i> space station. Crew returned Dec. 10, 1990, with Toyohiro Akiyama, Japanese cosmonaut and journalist in space.

## APPENDIX C

(Continued)

## U.S. and Russian Human Space Flights 1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Space Shuttle <i>Discovery</i> (STS-41)	Oct. 6, 1990	Richard N. Richards Robert D. Cabana Bruce E. Melnick William M. Shepherd Thomas D. Akers	4:2:10	Thirty-sixth STS flight. Ulysses spacecraft to investigate interstellar space and the Sun.
Space Shuttle <i>Atlantis</i> (STS-38)	Nov. 15, 1990	Richard O. Covey Frank L. Culbertson, Jr. Charles "Sam" Gemar Robert C. Springer Carl J. Meade	4:21:55	Thirty-seventh STS flight. Dedicated DoD mission.
Space Shuttle <i>Columbia</i> (STS-35)	Dec. 2, 1990	Vance D. Brand Guy S. Gardner Jeffrey A. Hoffman John M. "Mike" Lounge Robert A. R. Parker	8:23:5	Thirty-eighth STS flight. Astro-1 in cargo bay.
Soyuz TM-11	Dec. 2, 1990	Viktor Afanasyev Musa Manarov Toyohiro Akiyama	175:01:52	Docked with <i>Mir</i> space station. Toyohiro Akiyama returned Dec. 10, 1990, with previous <i>Mir</i> crew of Gennady Manakov and Gennady Strekalov.
Space Shuttle <i>Atlantis</i> (STS-37)	Apr. 5, 1991	Steven R. Nagel Kenneth D. Cameron Linda Godwin Jerry L. Ross Jay Apt	6:0:32	Thirty-ninth STS flight. Launched Gamma Ray Observatory to measure celestial gamma-rays.
Space Shuttle <i>Discovery</i> (STS-39)	Apr. 28, 1991	Michael L. Coats Blaine Hammond, Jr. Gregory L. Harbaugh Donald R. McMonagle Guion S. Bluford, Jr. Lacy Veach Richard J. Hieb	8:7:22	Fortieth STS flight. Dedicated DoD mission.
Soyuz TM-12	May 18, 1991	Anatoly Artsebarskiy Sergei Krikalev Helen Sharman	144:15:22	Docked with <i>Mir</i> space station. Helen Sharman first from United Kingdom to fly in space. Crew of Viktor Afanasyev, Musa Manarov, and Helen Sharman returned May 20, 1991. Artsebarskiy and Krikalev remained on board <i>Mir</i> , with Artsebarskiy returning Oct. 10, 1991, and Krikalev doing so Mar. 25, 1992.
Space Shuttle <i>Columbia</i> (STS-40)	June 5, 1991	Bryan D. O'Conner Sidney M. Gutierrez James P. Bagian Tamara E. Jernigan M. Rhea Seddon Francis A. "Drew" Gaffney Millie Hughes-Fulford	9:2:15	Forty-first STS flight. Carried Spacelab Life Sciences (SLS-1) in cargo bay.
Space Shuttle <i>Atlantis</i> (STS-43)	Aug. 2, 1991	John E. Blaha Michael A. Baker Shannon W. Lucid G. David Low James C. Adamson	8:21:21	Forty-second STS flight. Launched fourth Tracking and Data Relay Satellite (TDRS-5).
Space Shuttle <i>Discovery</i> (STS-48)	Sep. 12, 1991	John Creighton Kenneth Reightler, Jr. Charles D. Gemar James F. Buchli Mark N. Brown	5:8:28	Forty-third STS flight. Launched Upper Atmosphere Research Satellite (UARS).

APPENDIX C  
(Continued)  
**U.S. and Russian Human Space Flights**  
1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Soyuz TM-13	Oct. 2, 1991	Aleksandr Volkov Toktar Aubakirov (Kazakh Republic) Franz Viehboeck (Austria)	90:16:00	Docked with <i>Mir</i> space station. Crew returned Oct. 10, 1991, with Anatoly Artsebarsky in the TM-12 spacecraft.
Space Shuttle <i>Atlantis</i> (STS-44)	Nov. 24, 1991	Frederick D. Gregory Tom Henricks Jim Voss Story Musgrave Mario Runco, Jr. Tom Hennen	6:22:51	Forty-fourth STS flight. Launched Defense Support Program (DSP) satellite.
Space Shuttle <i>Discovery</i> (STS-42)	Jan. 22, 1992	Ronald J. Grabe Stephen S. Oswald Norman E. Thagard David C. Hilmers William F. Readdy Roberta L. Bondar Ulf Merbold (ESA)	8:1:12	Forty-fifth STS flight. Carried International Microgravity Laboratory-1 in cargo bay.
Soyuz TM-14	Mar. 17, 1992	Alexandr Viktorenko Alexandr Kaleri Klaus-Dietrich Flade (Germany)	145:15:11	First manned CIS space mission. Docked with <i>Mir</i> space station Mar. 19. The TM-13 capsule with Flade, Aleksandr Volkov, and Sergei Krikalev returned to Earth Mar. 25. Krikalev had been in space 313 days. Viktorenko and Kaleri remained on the <i>Mir</i> space station.
Space Shuttle <i>Atlantis</i> (STS-45)	Mar. 24, 1992	Charles F. Bolden Brian Duffy Kathryn D. Sullivan David C. Leestma Michael Foale Dirk D. Frimout Byron K. Lichtenberg	9:0:10	Forty-sixth STS flight. Carried Atmospheric Laboratory for Applications and Science (ATLAS-1).
Space Shuttle <i>Endeavour</i> (STS-49)	May 7, 1992	Daniel C. Brandenstein Kevin P. Chilton Richard J. Hieb Bruce E. Melnick Pierre J. Thuot Kathryn C. Thornton Thomas D. Akers	8:16:17	Forty-seventh STS flight. Reboosted a crippled INTELSAT VI communications satellite.
Space Shuttle <i>Columbia</i> (STS-50)	June 25, 1992	Richard N. Richards Kenneth D. Bowersox Bonnie Dunbar Ellen Baker Carl Meade	13:19:30	Forty-eighth STS flight. Carried U.S. Microgravity Laboratory-1.
Soyuz TM-15	July 27, 1992	Anatoly Solovyov Sergei Avdeyev Michel Tognini (France)	189:17:43	Docked with <i>Mir</i> space station Jul. 29. Tognini returned to Earth in TM-14 capsule with Aleksandr Viktorenko and Alexandr Kaleri. Solovyov and Avdeyev spent over six months in the <i>Mir</i> orbital complex and returned to Earth in the descent vehicle of the TM-15 spacecraft on Feb. 1, 1993.

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(Continued)

## U.S. and Russian Human Space Flights 1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Space Shuttle <i>Atlantis</i> (STS-46)	Jul. 31, 1992	Loren J. Shriver Andrew M. Allen Claude Nicollier (ESA) Marsha S. Ivins Jeffrey A. Hoffman Franklin R. Chang-Diaz Franco Malerba (Italy)	7:23:16	Forty-ninth STS flight. Deployed Tethered Satellite System-1 and Eureka-1.
Space Shuttle <i>Endeavour</i> (STS-47)	Sep. 12, 1992	Robert L. Gibson Curtis L. Brown, Jr. Mark C. Lee Jerome Apt N. Jan Davis Mae C. Jemison Mamoru Mohri	7:22:30	Fiftieth STS flight. Carried Spacelab J. Jemison first African American woman to fly in space. Mohri first Japanese to fly on NASA spacecraft. Lee and Davis first married couple in space together.
Space Shuttle <i>Columbia</i> (STS-52)	Oct. 22, 1992	James D. Wetherbee Michael A. Baker William M. Shepherd Tamara E. Jernigan Charles L. Veach Steven G. MacLean	9:20:57	Fifty-first STS flight. Studied influence of gravity on basic fluid and solidification processes using U.S. Microgravity Payload-1 in an international mission. Deployed second Laser Geodynamics Satellite and Canadian Target Assembly.
Space Shuttle <i>Discovery</i> (STS-53)	Dec. 2, 1992	David M. Walker Robert D. Cabana Guion S. Bluford, Jr. James S. Voss Michael Richard Clifford	7:7:19	Fifty-second STS flight. Deployed the last major DoD classified payload planned for Shuttle (DoD 1) with ten different secondary payloads.
Space Shuttle <i>Endeavour</i> (STS-54)	Jan. 13, 1993	John H. Casper Donald R. McMonagle Gregory J. Harbaugh Mario Runco, Jr. Susan J. Helms	6:23:39	Fifty-third STS flight. Deployed Tracking and Data Relay Satellite-6. Operated Diffused X-ray Spectrometer Hitchhiker experiment to collect data on stars and galactic gases.
Soyuz TM-16	Jan. 24, 1993	Gennady Manakov Aleksandr Poleshchuk	179:0:44	Docked with <i>Mir</i> space station Jan. 26. On July 22, 1993, the TM-16 descent cabin landed back on Earth with Manakov, Poleschuk, and French cosmonaut Jean-Pierre Haignere from Soyuz TM-17 on board.
Space Shuttle <i>Discovery</i> (STS-56)	Apr. 8, 1993	Kenneth D. Cameron Stephen S. Oswald C. Michael Foale Kenneth D. Cockerell Ellen Ochoa	9:6:9	Fifty-fourth STS flight. Completed second flight of Atmospheric Laboratory for Applications and Science and deployed SPARTAN-201.
Space Shuttle <i>Columbia</i> (STS-55)	Apr. 26, 1993	Steven R. Nagel Terence T. Henricks Jerry L. Ross Charles J. Precourt Bernard A. Harris, Jr. Ulrich Walter (Germany) Hans W. Schlegel (Germany)	9:23:39	Fifty-fifth STS flight. Completed second German microgravity research program in Spacelab D-2.
Space Shuttle <i>Endeavour</i> (STS-57)	June 21, 1993	Ronald J. Grabe Brian J. Duffy G. David Low Nancy J. Sherlock Peter J. K. Wisoff Janice E. Voss	9:23:46	Fifty-sixth STS flight. Carried Spacelab commercial payload module and retrieved European Retrievable Carrier in orbit since August 1992.

APPENDIX C  
(Continued)  
**U.S. and Russian Human Space Flights**  
1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Soyuz TM-17	July 1, 1993	Vasiliy Tsibliyev Aleksandr Serebrov Jean-Pierre Haignere	196:17:45	Docked with <i>Mir</i> space station July 3. Haignere returned to Earth with Soyuz TM-16. Serebrov and Tsibliyev landed in TM-17 spacecraft on Jan. 14, 1994.
Space Shuttle <i>Discovery</i> (STS-51)	Sep. 12, 1993	Frank L. Culbertson, Jr. William F. Readdy James H. Newman Daniel W. Bursch Carl E. Walz	9:20:11	Fifty-seventh STS flight. Deployed ACTS satellite to serve as testbed for new communications satellite technology and U.S./German ORFEUS-SPAS.
Space Shuttle <i>Columbia</i> (STS-58)	Oct. 18, 1993	John E. Blaha Richard A. Searfoss Shannon W. Lucid David A. Wolf William S. McArthur Martin J. Fettman	14:0:29	Fifty-eighth STS flight. Carried Spacelab Life Sciences-2 payload to determine the effects of microgravity on M. Rhea Seddon human and animal subjects.
Space Shuttle <i>Endeavour</i> (STS-61)	Dec. 2, 1993	Richard O. Covey Kenneth D. Bowersox Tom Akers Jeffrey A. Hoffman Kathryn C. Thornton Claude Nicollier F. Story Musgrave	10:19:58	Fifty-ninth STS flight. Restored planned scientific capabilities and reliability of the Hubble Space Telescope.
Soyuz TM-18	Jan. 8, 1994	Viktor Afanasyev Yuri Usachev Valery Polyakov	182:0:27	Docked with <i>Mir</i> space station Jan. 10. Afanasyev and Usachev landed in the TM-18 spacecraft on July 9, 1994. Polyakov remained aboard <i>Mir</i> in the attempt to establish a new record for endurance in space.
Space Shuttle <i>Discovery</i> (STS-60)	Feb. 3, 1994	Charles F. Bolden, Jr. Kenneth S. Reightler, Jr. N. Jan Davis Ronald M. Sega Franklin R. Chang-Diaz Sergei K. Krikalev (Russia)	8:7:9	Sixtieth STS flight. Carried the Wake Shield Facility to generate new semi-conductor films for advanced electronics. Also carried SPACEHAB. Krikalev's presence signified a new era in cooperation in space between Russia and the United States.
Space Shuttle <i>Columbia</i> (STS-62)	Mar. 9, 1994	John H. Casper Andrew M. Allen Pierre J. Thuot Charles D. Gemar Marsha S. Ivins	13:23:17	Sixty-first STS flight. Carried U.S. Microgravity Payload-2 to conduct experiments in materials processing, biotechnology, and other areas.
Space Shuttle <i>Endeavour</i> (STS-59)	Apr. 9, 1994	Sidney M. Gutierrez Kevin P. Chilton Jerome Apt Michael R. Clifford Linda M. Godwin Thomas D. Jones	11:5:50	Sixty-second STS flight. Carried the Space Radar Laboratory-1 to gather data on the Earth and the effects humans have on its carbon, water, and energy cycles.
Soyuz TM-19	July 1, 1994	Yuri I. Malenchenko Talgat A. Musabayev	125:22:53	Docked with <i>Mir</i> space station July 3. Both Malenchenko and Musabayev returned to Earth with the Soyuz TM-19 spacecraft, landing in Kazakhstan on Nov. 4 together with Ulf Merbold of Germany, who went up aboard Soyuz TM-20 on Oct 3, 1994. Merbold gathered biological samples on the effects of weightlessness on the human body in the first of two ESA missions to <i>Mir</i> to prepare for the International Space Station.

## APPENDIX C

(Continued)

## U.S. and Russian Human Space Flights 1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Space Shuttle <i>Columbia</i> (STS-65)	July 8, 1994	Robert D. Cabana James D. Halsell, Jr. Richard J. Hieb Carl E. Walz Leroy Chiao Donald A. Thomas Chiaki Naito-Mukai (Japan)	14:17:55	Sixty-third STS flight. Carried International Microgravity Laboratory-2 to conduct research into the behavior of materials and life in near weightlessness.
Space Shuttle <i>Discovery</i> (STS-64)	Sep. 9, 1994	Richard N. Richards L. Blaine Hammond, Jr. J. M. Linenger Susan J. Helms Carl J. Meade Mark C. Lee	10:22:50	Sixty-fourth STS flight. Used LIDAR In-Space Technology Experiment to perform atmospheric research. Included the first untethered spacewalk by astronauts in over 10 years.
Space Shuttle <i>Endeavour</i> (STS-68)	Sep. 30, 1994	Michael A. Baker Terrence W. Wilcutt Thomas D. Jones Steven L. Smith Daniel W. Bursch Peter J. K. Wisoff	11:5:36	Sixty-fifth STS flight. Used Space Radar Laboratory-2 to provide scientists with data to help distinguish human-induced environmental change from other natural forms of change.
Soyuz TM-20	Oct. 3, 1994	Alexsandr Viktorenko Yelena Kondakova Ulf Merbold (ESA)	*	Soyuz TM-19 returned to Earth on Nov. 4, 1994, with Yuri Malenchenko, Taldat Musabayev, and Ulf Merbold. Valeriy Polyakov remained aboard <i>Mir</i> .
Space Shuttle <i>Atlantis</i> (STS-66)	Nov. 3, 1994	Donald R. McMonagle Curtis L. Brown, Jr. Ellen Ochoa Joseph R. Tanner Jean-Francois Clervoy (ESA) Scott E. Parazynski	10:22:34	Sixty-sixth STS flight. Three main payloads: the third Atmospheric Laboratory for Applications and Science (ATLAS-3), the first Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere-Shuttle Pallet Satellite (CRISTA-SPAS-1), and the Shuttle Solar Backscatter Ultraviolet (SSBUV) spectrometer. Astronauts also conducted protein crystal growth experiments.
Space Shuttle <i>Discovery</i> (STS-63)	Feb. 3, 1995	James D. Wetherbee Eileen M. Collins Bernard A. Harris, Jr. C. Michael Foale Janice E. Voss Vladimir G. Titov (Russia)	8:6:28	Sixty-seventh STS flight. Primary objective: first close encounter in nearly 20 years between American and Russian spacecraft as a prelude to establishment of International Space Station. (Shuttle flew close by to <i>Mir</i> .) Main Payloads: Spacehab 3 experiments and Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 204, Solid Surface Combustion Experiment (SSCE), and Air Force Maui Optical Site (AMOS) Calibration Test. Also launched very small Orbital Debris Radar Calibration Spheres (ODERACS).
Space Shuttle <i>Endeavour</i> (STS-67)	Mar. 2, 1995	Stephen S. Oswald William G. Gregory John M. Grunsfeld Wendy B. Lawrence Tamara E. Jernigan Ronald A. Parise Samuel T. Durrance	16:15:8	Sixty-eighth STS flight. Longest Shuttle mission to date. Primary payload was a trio of ultraviolet telescopes called <i>Astro-2</i> .

APPENDIX C  
(Continued)  
**U.S. and Russian Human Space Flights**  
1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Soyuz TM-21	Mar. 14, 1995	Vladimir Dezhurov Gennadi Strekalov Norman Thagard (U.S.)	*	Thagard was the first American astronaut to fly on a Russian rocket and to stay on the <i>Mir</i> space station. Soyuz TM-20 returned to Earth on Mar. 22, 1995, with Valeriy Polyakov, Aleksandr Viktorenko, and Yelena Kondakova. Polyakov set world record by remaining in space for 438 days.
Space Shuttle <i>Atlantis</i> (STS-71)	June 27, 1995	Robert L. Gibson Charles J. Precourt Ellen S. Baker Gregory Harbaugh Bonnie J. Dunbar	9:19:22	Sixty-ninth STS flight and one hundredth U.S. human spaceflight. Docked with <i>Mir</i> space station. Brought up <i>Mir</i> 19 crew (Anatoly Y. Solovyev and Nikolai M. Budarin). Returned to Earth with <i>Mir</i> 18 crew (Vladimir N. Dezhurov, Gennady M. Strekalov, and Norman Thagard). Thagard set an American record by remaining in space for 115 days.
Space Shuttle <i>Discovery</i> (STS-70)	July 13, 1995	Terence Henricks Kevin R. Kregel Nancy J. Currie Donald A. Thomas Mary Ellen Weber	8:22:20	Seventieth STS flight. Deployed Tracking and Data Relay Satellite (TDRS). Also conducted various biomedical experiments.
Soyuz TM-22	Sep. 3, 1995	Yuri Gidzenko Sergei Avdeev Thomas Reiter (ESA)	*	Soyuz TM-21 returned to Earth on Sep. 11, 1995, with <i>Mir</i> 19 crew (Anatoly Solovyev and Nikolay Budarin).
Space Shuttle <i>Endeavour</i> (STS-69)	Sep. 7, 1995	David M. Walker Kenneth D. Cockrell James S. Voss James H. Newman Michael L. Gernhardt	10:20:28	Seventy-first STS flight. Deployed Wake Shield Facility (WSF-2) and SPARTAN 201-03.
Space Shuttle <i>Columbia</i> (STS-73)	Oct. 20, 1995	Kenneth D. Bowersox Kent V. Rominger Catherine G. Coleman Michael Lopez-Alegria Kathryn C. Thornton Fred W. Leslie Albert Sacco, Jr.	15:21:52	Seventy-second STS flight. Carried out microgravity experiments with the U.S. Microgravity Laboratory (USML-2) payload.
Space Shuttle <i>Atlantis</i> (STS-74)	Nov. 12, 1995	Kenneth D. Cameron James D. Halsell, Jr. Chris A. Hadfield (CSA) Jerry L. Ross William S. McArthur, Jr.	8:4:31	Seventy-third STS flight. Docked with <i>Mir</i> space station as part of International Space Station (ISS) Phase I efforts.
Space Shuttle <i>Endeavour</i> (STS-72)	Jan. 11, 1996	Brian Duffy Brent W. Jett, Jr. Leroy Chiao Winston E. Scott Koichi Wakata (Japan) Daniel T. Barry	8:22:1	Seventy-fourth STS flight. Deployed OAST Flyer. Retrieved previously launched Japanese Space Flyer Unit satellite. Crew performed spacewalks to build experience for ISS construction.
Soyuz TM-23	Feb. 21, 1996	Yuri Onufrienko Yuri Usachyov	*	Soyuz TM-22 returned to Earth on Feb. 29, 1996, with <i>Mir</i> 20 crew (Yuri Gidzenko, Sergei Avdeev, and Thomas Reiter).

## APPENDIX C

(Continued)

## U.S. and Russian Human Space Flights 1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Space Shuttle <i>Columbia</i> (STS-75)	Feb. 22, 1996	Andrew M. Allen Scott J. Horowitz Jeffrey A. Hoffman Maurizio Cheli (ESA) Claude Nicollier (ESA) Franklin R. Chang-Diaz Umberto Guidoni (ESA)	13:16:14	Seventy-fifth STS flight. Deployed Tethered Satellite System, U.S. Microgravity Payload (USMP-3), and protein crystal growth experiments.
Space Shuttle <i>Atlantis</i> (STS-76)	Mar. 22, 1996	Kevin P. Chilton Richard A. Searfoss Linda M. Godwin Michael R. Clifford Ronald M. Sega Shannon W. Lucid**	9:5:16	Seventy-sixth STS flight. Docked with <i>Mir</i> space station and left astronaut Shannon Lucid aboard <i>Mir</i> . Also carried SPACEHAB module.
Space Shuttle <i>Endeavour</i> (STS-77)	May 19, 1996	John H. Casper Curtis L. Brown Andrew S. W. Thomas Daniel W. Bursch Mario Runco, Jr. Marc Garneau (CSA)	10:2:30	Seventy-seventh STS flight. Deployed SPARTAN/Inflatable Antenna Experiment, SPACEHAB, and PAMS-STU payloads.
Space Shuttle <i>Columbia</i> (STS-78)	June 20, 1996	Terrence T. Henricks Kevin Kregel Richard M. Linnehan Susan J. Helms Charles E. Brady, Jr. Jean-Jacques Favier (CSA) Robert B. Thirsk (ESA)	16:21:48	Seventy-eighth STS flight. Set Shuttle record for then-longest flight. Carried Life and Microgravity Sciences Spacelab.
Soyuz TM-24	Aug. 17, 1996	Claudie Andre-Deshays (ESA) Valery Korzun Alexander Kaleri	*	Soyuz TM-23 returned to Earth on Sep. 2, 1996, with Claudie Andre-Deshays, Yuri Onufrienko, and Yuri Usachev.
Space Shuttle <i>Atlantis</i> (STS-79)	Sep. 16, 1996	William F. Readdy Terrence W. Wilcutt Jerome Apt Thomas D. Akers Carl E. Walz John E. Blaha** Shannon W. Lucid***	10:3:19	Seventy-ninth STS flight. Docked with <i>Mir</i> space station. Picked up astronaut Shannon Lucid and dropped off astronaut John Blaha.
Space Shuttle <i>Columbia</i> (STS-80)	Nov. 19, 1996	Kenneth D. Cockrell Kent V. Rominger Tamara E. Jernigan Thomas David Jones F. Story Musgrave	17:15:53	Set record for longest Shuttle flight. At age 61, Musgrave became oldest person to fly in space. He also tied record for most space flights (six) by a single person. Crew successfully deployed ORFEUS-SPAS II ultraviolet observatory and Wake Shield Facility payloads.
Space Shuttle <i>Atlantis</i> (STS-81)	Jan. 12, 1997	Michael A. Baker Brent W. Jett Peter J.K. "Jeff" Wisoff John M. Grunsfeld Marsha S. Ivins Jerry M. Linenger** John E. Blaha***	10:4:56	Fifth Shuttle mission to <i>Mir</i> . Jerry Linenger replaced John Blaha as U.S. resident on <i>Mir</i> .

APPENDIX C  
(Continued)  
**U.S. and Russian Human Space Flights**  
1961–September 30, 1997

Spacecraft	Launch Date	Crew	Flight Time (days:hrs:min)	Highlights
Soyuz TM-25	Feb. 10, 1997	Vasily Tsibliyev Aleksandr Lazutkin Reinhold Ewald	*	Soyuz TM-24 returned to Earth on March 2, 1997, with Reinhold Ewald, Valery Korzun, and Alexandr Kaleri.
Space Shuttle <i>Discovery</i> (STS-82)	Feb. 11, 1997	Kenneth D. Bowersox Scott J. Horowitz Joseph R. Tanner Steven A. Hawley Gregory J. Harbaugh Mark C. Lee Steven L. Smith	9:23:36	Crew successfully performed second servicing mission of the Hubble Space Telescope.
Space Shuttle <i>Columbia</i> (STS-83)	Apr. 4, 1997	James D. Halsell, Jr. Susan L. Still Janice Voss Michael L. Gernhardt Donald A. Thomas Roger K. Crouch Gregory T. Linteris	3:23:34	Crew deployed a Spacelab module configured as the first Microgravity Science Laboratory. Shuttle fuel cell malfunction necessitated an early termination of the mission.
Space Shuttle <i>Atlantis</i> (STS-84)	May 15, 1997	Charles J. Precourt Eileen Marie Collins Jean-François Clervoy Carlos I. Noriega Edward Tsang Lu Elena V. Kondakova Michael Foale** Jerry M. Linenger***	9:5:21	Sixth Shuttle mission to <i>Mir</i> . Michael Foale replaced Jerry Linenger on <i>Mir</i> .
Space Shuttle <i>Columbia</i> (STS-94)	July 1, 1997	James D. Halsell, Jr. Susan L. Still Janice Voss Michael L. Gernhardt Donald A. Thomas Roger K. Crouch Gregory T. Linteris	15:16:45	Reflight of STS-83 and the same payload, the Microgravity Science Laboratory. Mission proceeded successfully.
Soyuz TM-26	Aug. 5, 1997	Anatoly Solovyev Pavel Vinogradov	*	Soyuz TM-25 returned to Earth on August 14, 1997, with Vasily Tsibliyev and Alesandr Lazutkin.
Space Shuttle <i>Discovery</i> (STS-85)	Aug. 7, 1997	Curtis L. Brown, Jr. Kent V. Rominger N. Jan Davis Robert L. Curbeam, Jr. Stephen K. Robinson Bjarni V. Tryggvason	11:20:27	Crew successfully deployed two payloads: CRISTA-SPAS-2 on infrared radiation and an international Hitchhiker package of four experiments on ultraviolet radiation. The crew also successfully performed the Japanese Manipulator Flight Demonstration of a robotic arm.
Space Shuttle <i>Atlantis</i> (STS-86)	Sep. 25, 1997	James D. Wetherbee Michael J. Bloomfield Scott E. Parazynski Vladimir Titov Jean-Loup Chretien Wendy B. Lawrence David A. Wolf** C. Michael Foale***	10:19:21	Seventh Shuttle docking with <i>Mir</i> . David Wolf replaced Michael Foale on <i>Mir</i> . Parazynski and Titov performed a spacewalk to retrieve four <i>Mir</i> Environmental Effects Payload experiments from the exterior of the docking module and left a solar array cover cap for possible future repair of the damaged <i>Spektr</i> module.

\* *Mir* crew members stayed for various and overlapping lengths of time.

\*\* Flew up on Space Shuttle; remained in space aboard Russian *Mir* space station.

\*\*\* Returned to Earth via Space Shuttle from Russian *Mir* space station.

## APPENDIX D

## U.S. Space Launch Vehicles

Vehicle	Stages: Engine/Motor	Propellant <sup>a</sup>	Thrust (kilonewtons) <sup>b, c</sup>	Max. Dia x Height (m)	Max. Payload (kg) <sup>d</sup>			First Launch <sup>f</sup>
					185-km Orbit	Geosynch. Transfer Orbit	Sun- Synch. Orbit <sup>e</sup>	
Pegasus				6.71x15.5 <sup>h</sup>	380 280 <sup>e</sup>	—	210	1990
	1. Orion 50S	Solid	484.9	1.28x8.88				
	2. Orion 50	Solid	118.2	1.28x2.66				
	3. Orion 38	Solid	31.9	0.97x1.34				
Pegasus XL				6.71x16.93	460 350 <sup>e</sup>	—	335	1994 <sup>g</sup>
	1. Orion 50S-XL	Solid	743.3	1.28x10.29				
	2. Orion 50-XL	Solid	201.5	1.28x3.58				
	3. Orion 38	Solid	31.9	0.97x1.34				
Taurus				2.34x28.3	1,400 1,080 <sup>c</sup>	255	1,020	Not scheduled
	0. Castor 120	Solid	1,687.7	2.34x11.86				
	1. Orion 50S	Solid	580.5	1.28x8.88				
	2. Orion 50	Solid	138.6	1.28x2.66				
	3. Orion 38	Solid	31.9	0.97x1.34				
Delta II (7920, 7925)				2.44x29.70	5,089 3,890 <sup>c</sup>	1,842 <sup>j</sup>	3,175	1990, Delta-7925 [1960, Delta]
	1. RS-270/A Hercules GEM (9)	LOX/RP-1 Solid	1,043.0 (SL) 487.6 (SL)	3.05x38.1 1.01x12.95				
	2. AJ10-118K	N204/A-50	42.4	2.44x5.97				
	3. Star 48B <sup>i</sup>	Solid	66.4	1.25x2.04				
Atlas E				3.05x28.1	820 <sup>c</sup> 1,860 <sup>e, k</sup>	—	910 <sup>k</sup>	1968, Atlas F [1958, Atlas LV-3A]
	1. Atlas: MA-3	LOX/RP-1	1,739.5 (SL)	3.05x21.3				
Atlas I				4.2x43.9	—	2,255	—	1990, I [1966, Atlas Centaur]
	1. Atlas: MA-5	LOX/RP-1	1,952.0 (SL)	3.05x22.16				
	2. Centaur I: RL10A-3-3A (2)	LOX/LH <sub>2</sub>	73.4/ engine	3.05x9.14				
Atlas II				4.2x47.5	6,580 5,510 <sup>e</sup>	2,810	4,300	1991, II [1966, Atlas Centaur]
	1. Atlas: MA-5A	LOX/RP-1	2,110.0 (SL)	3.05x24.9				
	2. Centaur II: RL10A-3-3A (2)	LOX/LH <sub>2</sub>	73.4/engine	3.05x10.05				
Atlas IIA				4.2x47.5	6,828 6,170 <sup>e</sup>	3,062	4,750	1992, Atlas IIA [1966, Atlas Centaur]
	1. Atlas: MA-5A	LOX/RP-1	2,110.0 (SL)	3.05x24.9				
	2. Centaur II: RL10A-4 (2)	LOX/LH <sub>2</sub>	92.53/engine	3.05x10.05				
Atlas IIAS				4.2x47.5	8,640 7,300 <sup>e</sup>	3,606	5,800	1993, IIAS [1966, Atlas Centaur]
	1. Atlas: MA-5A Castor IVA (4) <sup>j</sup>	LOX/RP-1 Solid	2,110.0 (SL) 433.6 (SL)	3.05x24.9 1.01x11.16				
	2. Centaur II: RL10A-4 (2)	LOX/LH <sub>2</sub>	92.53/engine	3.05x10.05				

APPENDIX D  
(Continued)  
**U.S. Space Launch Vehicles**

Vehicle	Stages: Engine/Motor	Propellant <sup>a</sup>	Thrust (kilonewtons) <sup>b, c</sup>	Max. Dia x Height (m)	Max. Payload (kg) <sup>d</sup>			First Launch <sup>f</sup>
					185-km Orbit	Geosynch. Transfer Orbit	Sun- Synch. Orbit <sup>e</sup>	
Titan II				3.05x42.9	1,905 <sup>e</sup>	—	—	1988, Titan II SLV [1964, Titan II Gemini]
1.	LR-87-AJ-5 (2)	N204/A-50	1,045.0	3.05x21.5				
2.	LR-91-AJ-5	N204/A-50	440.0	3.05x12.2				
Titan III				3.05x47.3	14,515	5,000 <sup>l</sup>	—	1989, Titan III [1964, Titan IIIA]
0.	Titan III SRM (2) (5-1/2 segments)	Solid	6,210.0	3.11x27.6				
1.	LR87-AJ-11 (2)	N204/A-50	1,214.5	3.05x24.0				
2.	LR91-AJ-11	N204/A-50	462.8	3.05x10.0				
Titan IV				3.05x62.2	17,700	6,350 <sup>m</sup>	—	1989, Titan IV
0.	Titan IV SRM (2) (7 segments)	Solid	7,000.0	3.11x34.1	14,110 <sup>e</sup>			
1.	LR87-AJ-11 (2)	N204/A-50	1,214.5	3.05x26.4				
2.	LR91-AJ-11	N204/A-50	462.8	3.05x10.0				
Titan IV/ Centaur				4.3x62.2	—	5,760 <sup>a</sup>	—	1994, Titan IV Centaur
0.	Titan IV SRM (2) (7 segments)	Solid	7,000.0	3.11x34.1				
1.	LR87-AJ-11 (2)	N204/A-50	1,214.5/engine	3.05x26.4				
2.	LR91-AJ-11(1)	N204/A-50	462.5	3.05x10.0				
3.	Centaur: RL-10A-3-3A	LOX/LH2	73.4	4.3x9.0				
4.	SRMU (3 segments)		7690	3.3x34.3				
Space Shuttle <sup>n</sup>				23.79x56.14 <sup>h</sup>	24,900 <sup>o</sup>	5,900 <sup>p</sup>	—	1981, Columbia
1.	SRB: Shuttle SRB (2)	Solid	11,790.0 (SL)	3.70x45.46				
2.	Orbiter/ET: SSME (3)	LOX/LH <sub>2</sub>	1,668.7 (SL)	8.41x47.00 (ET)				
3.	Orbiter/OMS: OMS engines (2)	N <sub>2</sub> O <sub>4</sub> /MMH	26.7	23.79x37.24 <sup>h</sup> (orbiter)				

## APPENDIX D

(Continued)

## U.S. Space Launch Vehicles

## NOTES:

- a. Propellant abbreviations used are as follows:  
 A-50 = Aerozine 50 (50% Monomethyl Hydrazine,  
 50% Unsymmetrical Dimethyl Hydrazine)  
 RP-1 = Rocket Propellant 1 (kerosene)  
 Solid = Solid Propellant (any type)  
 LH<sub>2</sub> = Liquid Hydrogen  
 LOX = Liquid Oxygen  
 MMH = Monomethyl Hydrazine  
 N<sub>2</sub>O<sub>4</sub> = Nitrogen Tetroxide
- b. Thrust at vacuum except where indicated at sea level (SL).
- c. Thrust per engine. Multiply by number of engines for thrust per stage.
- d. Inclination of 28.5° except where indicated.
- e. Polar launch from Vandenberg AFB, CA.
- f. First successful orbital launch [ditto of initial version].
- g. First launch was a failure
- h. Diameter dimension represents vehicle wing span.
- i. Applies to Delta II-7925 version only.
- j. Two Castor IVA motors ignited at lift-off. Two Castor IVA motors ignited at approximately 57 seconds into flight.
- k. With TE-M-364-4 upper stage.
- l. With Transfer Orbit Stage.
- m. With appropriate upper stage.
- n. Space Shuttle Solid Rocket Boosters fire in parallel with the Space Shuttle Main Engines (SSME), which are mounted on the aft end of the Shuttle Orbiter Vehicle and burn fuel, and oxidizer from the External Tank. The boosters stage first, with SSME's continuing to fire. The External Tank stages next, just before the orbiter attains orbit. The Orbiter Maneuvering Subsystem is then used to maneuver or change the orbit of the Orbiter Vehicle.
- o. 204-km circular orbit.
- p. With Inertial Upper Stage or Transfer Orbit Stage.

**NOTE: Data should not be used for detailed NASA mission planning without concurrence of the Director of Space Transportation System Support Programs.**

## Space Activities of the U.S. Government

HISTORICAL BUDGET SUMMARY—BUDGET AUTHORITY  
(in millions of real-year dollars)

FY	NASA Total	NASA Space <sup>b</sup>	DoD	Other <sup>c</sup>	DoE	DoC	DoI	USDA	NSF <sup>a</sup>	DoT	EPA <sup>d</sup>	Total Space
1959	331	261	490	34	34							785
1960	524	462	561	43	43				0.1			1,066
1961	964	926	814	69	68				1			1,809
1962	1,825	1,797	1,298	200	148	51			1			3,295
1963	3,673	3,626	1,550	259	214	43			2			5,435
1964	5,100	5,016	1,599	216	210	3			3			6,831
1965	5,250	5,138	1,574	244	229	12			3			6,956
1966	5,175	5,065	1,689	217	187	27			3			6,971
1967	4,966	4,830	1,664	216	184	29			3			6,710
1968	4,587	4,430	1,922	177	145	28	0.2	1	3			6,529
1969	3,991	3,822	2,013	141	118	20	0.2	1	2			5,976
1970	3,746	3,547	1,678	115	103	8	1	1	2			5,340
1971	3,311	3,101	1,512	127	95	27	2	1	2			4,740
1972	3,307	3,071	1,407	97	55	31	6	2	3			4,575
1973	3,406	3,093	1,623	109	54	40	10	2	3			4,825
1974	3,037	2,759	1,766	116	42	60	9	3	2			4,641
1975	3,229	2,915	1,892	106	30	64	8	2	2			4,913
1976	3,550	3,225	1,983	111	23	72	10	4	2			5,319
TQ*	932	849	460	32	5	22	3	1	1			1,341
1977	3,818	3,440	2,412	131	22	91	10	6	2			5,983
1978	4,060	3,623	2,738	157	34	103	10	8	2			6,518
1979	4,596	4,030	3,036	177	59	98	10	8	2			7,243
1980	5,240	4,680	3,848	233	40	93	12	14	74			8,761
1981	5,518	4,992	4,828	233	41	87	12	16	77			10,053
1982	6,044	5,528	6,679	311	61	145	12	15	78			12,518
1983	6,875	6,328	9,019	325	39	178	5	20	83			15,672
1984	7,458	6,858	10,195	392	34	236	3	19	100			17,445
1985	7,573	6,925	12,768	580	34	423	2	15	106			20,273
1986	7,807	7,165	14,126	473	35	309	2	23	104			21,764
1987	10,923	9,809	16,287	462	48	278	8	19	108	1		26,558
1988	9,062	8,322	17,679	737	241	352	14	18	111	1		26,738
1989	10,969	10,097	17,906	560	97	301	17	21	116	3	5	28,563
1990	12,324	11,460	15,616	512	79	243	31	25	125	4	5	27,588
1991	14,016	13,046	14,181	697	251	251	29	26	131	4	5	27,924
1992	14,317	13,199	15,023	769	223	327	34	29	145	4	7	28,991
1993	14,310	13,064	14,106	698	165	324	33	25	139	4	8	27,868
1994	14,570	13,022	13,166	601	74	312	31	31	140	5	8	26,789
1995	13,854	12,543	10,644	629	60	352	31	32	141	6	7	23,816
1996	13,884	12,569	11,514	750	46	472	36	37	147	6	6	24,833
1997	13,709	12,457	11,727	727	35	448	42	39	151	6	6	24,911

\* Transition Quarter

- NSF has recalculated its space expenditures since 1980, making them significantly higher than reported in previous years.
- Includes \$2.1 billion for replacement of Space Shuttle *Challenger*.
- "Other" column is the total of the non-NASA, non-DoD budget authority figures that appear in succeeding columns. The total is sometimes different from the sum of the individual figures because of rounding. The "Total Space" column does not include the "NASA Total" column because it includes budget authority for aeronautics as well as in space.
- EPA has recalculated its aeronautics and space expenditures since 1989, making them significantly higher than reported in previous years.

SOURCE: Office of Management and Budget

## APPENDIX E-1B

## Space Activities of the U.S. Government

BUDGET AUTHORITY IN MILLIONS OF EQUIVALENT FY 1997 DOLLARS  
(adjusted for inflation)

FY	Inflation Factors	NASA Total	NASA Space	DoD	Other	DoE	DoC	DoI	USDA	NSF	DoT	EPA	Total Space
1959	4.8506	1,606	1,266	2,377	165	165							3,808
1960	4.7579	2,493	2,198	2,669	205	205				0.5			5,072
1961	4.7149	4,545	4,366	3,838	325	321				5			8,529
1962	4.6469	8,481	8,350	6,032	929	688	237			5			15,311
1963	4.5942	16,875	16,659	7,121	1,190	983	198			9			24,970
1964	4.5409	23,159	22,777	7,261	981	954	14			14			31,019
1965	4.4796	23,518	23,016	7,051	1,093	1,026	54			13			31,160
1966	4.4057	22,800	22,315	7,441	956	824	119			13			30,712
1967	4.3070	21,388	20,803	7,167	930	792	125			13			28,900
1968	4.1756	19,154	18,498	8,026	740	605	117	0.8	4	13			27,263
1969	4.0223	16,053	15,373	8,097	568	475	80	0.8	4	8			24,038
1970	3.8525	14,431	13,665	6,464	443	397	31	4	4	8			20,572
1971	3.6594	12,116	11,348	5,533	465	348	99	7	4	7			17,346
1972	3.4803	11,510	10,688	4,897	338	191	108	21	7	10			15,923
1973	3.3220	11,315	10,275	5,392	362	179	133	33	7	10			16,029
1974	3.1821	9,664	8,779	5,620	369	134	191	29	10	6			14,768
1975	2.9674	9,582	8,650	5,614	315	89	190	24	6	6			14,579
1976	2.6904	9,551	8,677	5,335	299	62	194	27	11	5			14,310
TQ	2.5092	2,339	2,130	1,154	80	13	55	8	3	3			3,365
1977	2.4307	9,280	8,362	5,863	318	53	221	24	15	5			14,543
1978	2.3318	9,467	8,448	6,385	366	79	240	23	19	5			15,199
1979	2.1783	10,012	8,779	6,613	386	129	213	22	17	4			15,778
1980	2.0119	10,542	9,416	7,742	469	80	187	24	28	149			17,626
1981	1.8476	10,195	9,223	8,920	430	76	161	22	30	142			18,574
1982	1.6819	10,166	9,298	11,234	523	103	244	20	25	131			21,054
1983	1.5709	10,800	9,941	14,168	511	61	280	8	31	130			24,620
1984	1.5016	11,199	10,298	15,309	589	51	354	5	29	150			26,195
1985	1.4457	10,948	10,011	18,459	839	49	612	3	22	153			29,309
1986	1.3976	10,911	10,013	19,742	661	49	432	3	32	145			30,416
1987	1.3589	14,843	13,329	22,132	628	65	378	11	26	147	1		36,089
1988	1.3207	11,968	10,991	23,349	973	318	465	18	24	147	1		35,313
1989	1.2764	14,001	12,888	22,855	715	124	384	22	27	148	4	6	36,457
1990	1.2246	15,092	14,034	19,123	627	97	298	38	31	153	5	6	33,784
1991	1.1758	16,480	15,340	16,674	820	295	295	34	31	154	5	6	32,833
1992	1.1274	16,141	14,880	16,937	867	251	369	38	33	163	5	8	32,684
1993	1.0984	15,718	14,349	15,494	767	181	356	36	27	153	4	9	30,610
1994	1.0725	15,626	13,966	14,120	645	79	335	33	33	150	5	9	28,731
1995	1.0456	14,486	13,115	11,130	657	63	368	32	33	147	6	7	24,902
1996	1.0220	14,190	12,846	11,768	767	47	482	37	38	150	6	6	25,380
1997	1.0000	13,709	12,457	11,727	727	35	448	42	39	151	6	6	24,911

SOURCE: Office of Management and Budget

## Federal Space Activities Budget

(in millions of dollars by fiscal year)

Federal Agencies	Budget Authority			Budget Outlays		
	1995 actual	1996 actual	1997 est.	1995 actual	1996 actual	1997 est.
NASA .....	12,543	12,569	12,457	12,593	12,694	13,055
Defense .....	10,644	11,514	11,727	11,494	11,353	11,959
Energy .....	60	46	35	70	46	37
Commerce .....	352	472	448	330	354	336
Interior .....	31	36	42	31	36	42
Agriculture .....	32	37	39	32	37	39
Transportation .....	6	6	6	5	6	6
EPA .....	7	6	6	7	7	6
NSF .....	141	147	151	138	142	146
TOTAL .....	23,816	24,833	24,911	24,700	24,675	25,626

SOURCE: Office of Management and Budget.

## APPENDIX E-3

## Federal Aeronautics Budget

*(in millions of dollars by fiscal year)*

Federal Agencies	Budget Authority			Budget Outlays		
	1995 actual	1996 actual	1997 est.	1995 actual	1996 actual	1997 est.
NASA <sup>a</sup> .....	1,310	1,315	1,252	1,153	1,187	1,302
Defense <sup>b</sup> .....	7,196	6,792	6,323	7,132	6,974	6,600
Transportation <sup>c</sup> .....	2,212	2,052	2,146	2,870	2,676	2,528
TOTAL .....	10,718	10,159	9,721	11,155	10,837	10,430

a. Research, Development, Construction of Facilities, Research and Program Management

b. Research, Development, Testing, and Evaluation of aircraft and related equipment.

c. Federal Aviation Administration: Research, Engineering, and Development; Facilities, Engineering, and Development

SOURCE: Office of Management and Budget.